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Lake Okeechobee Supply-Side Management

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Executive Summary

Pursuant to Sections 373.175 and 373.246, F.S., the South Florida Water Management District implements water shortage restrictions to prevent serious harm to the water resources and to equitably distribute available water supplies to consumptive and non-consumptive users. These types of restrictions may be used for the purpose of managing water supplies in Lake Okeechobee as outlined in Rule 40E-21, F.A.C. The specific guidelines for implementing these water restrictions based on water use type and severity of drought are provided in the SFWMD Water Shortage Plan. As part of this overall plan, the Supply Side Management protocol outlined in this document is designed as a guideline for implementing water use restrictions and management alternatives during declared water shortages. The specific method for implementing restrictions will be determined through governing board order.

The operation of Lake Okeechobee under low water levels was formally documented in Hall (1991). In that report, referred to as the "yellow book" or SSM1991, the need to manage water supplies in the lake for anticipated high-demand periods (dry season) was recognized. Supply Side Management, a computational method for allocating water under declared water shortages to the Lake Okeechobee and Lower East Coast Service Areas, was documented. This method incorporated some flexibility and responsiveness to allow for short-term fluctuations in supply and demand as well as knowledge of the actual physical limitations of the water delivery system. During the most recent drought, a record low Lake Okeechobee water level of 8.97 ft NGVD was set on May 24, 2001. The Supply Side Management (SSM) policy document written in 1991 was used as a guide to assist the District's Drought Management Team in apportioning water to the several users of lake water during the 2000-2001 dry season. In the process, a better understanding of the system was realized and improvements to the current implementation of Supply Side Management were discussed.

The 1991 method uses normal climatological conditions, does not account for tributary inflow to the lake, and does not address the water consumption by all current users of lake water and by resource protection needs. In addition, the computational method is not flexible enough to deal with short-term fluctuations in supply and demand. As a means of addressing these issues and to account for recent changes to water shortage rules, the Supply Side Management computational procedure and methodology is revised and updated in this document. The revised methodology makes use of the new concept of "share accounts" that represent the volumes of water available to different users of lake water with consideration for both drought severity and user demand. This methodology provides increased flexibility in dealing with short-term fluctuations in demand, accounts for previously omitted and new components of the lake water budget and incorporates consideration for many uses of lake water outside of agriculture and the Lower East Coast service areas (e.g. environmental deliveries, navigational requirements, etc.). Additionally, the data used in the computational method has been revised to more accurately reflect drought conditions.

I. Introduction

A. Philosophy

To equitably distribute the scarce resource of Lake Okeechobee water during drought conditions, a balanced water shortage policy must be implemented. As a major component of this policy, the Lake Okeechobee Supply-Side Management Plan (SSM) attempts to estimate demand among lake water users and quantifies allocations for each user as a function of existing supply within the lake. The primary rationale behind Supply-Side Management as originally outlined in Hall (1991) is a "live within our means" concept. During the Supply Side Management dry season (October through May), a natural decrease in rainfall and thus a recession in lake stage occurs. It is therefore necessary to prudently budget water supply deliveries during times of shortage in order to reserve water for future demands as well as to reduce the undesirable impacts to lake environment, navigation, recreational uses and others that result from extremely low lake stages.

While SSM1991 outlines a computational procedure for allocating water to agricultural users of lake water during declared water shortages while making considerations for users and water resource protection in the Lower East Coast service areas, experience from the 2000 drought indicates that the method does not provide a complete picture of the factors influencing Lake Okeechobee. The 1991 method uses normal climatological conditions, does not account for tributary inflow to the lake, and does not address the water consumption by all current users of lake water and by resource protection needs. In addition, the computational method is not flexible enough to deal with short-term fluctuations in supply and demand.

As a means of addressing these issues and to account for recent changes to water shortage rules, the Supply Side Management computational procedure and methodology is revised and updated in this document. This new methodology does not have the restrictive computational limits of SSM1991. Rather, it provides flexibility by adjusting to changes in both drought severity and user demand. It accounts for previously omitted and new components of the lake water budget and incorporates consideration for many uses of lake water outside of agriculture and the Lower East Coast service areas. Additionally, the data used in the computational method has been revised to more accurately reflect drought conditions.

B. Relationship to Other Rules and Guidelines

The management of Lake Okeechobee is based on providing flood protection for lands adjacent to the lake from lake waters and wind-driven tides, as well as on storing water to meet agricultural, urban and environmental needs in a significant portion of south Florida. Figure 1 shows the zones associated with managing water levels in Lake Okeechobee. The Water Supply/Environmental (WSE) regulation schedule (USACE, 2000) is primarily used for managing high lake stages and was implemented in July 2000. The WSE schedule (Zones A through D in Figure 1) and associated release rules for lake pumps, locks, and spillways are used to mitigate the impacts of high lake water levels. Within the constraints of the WSE schedule, Adaptive Protocols for Lake Okeechobee have been proposed to help “balance the missions of the SFWMD for water supply, flood protection, and environmental protection” (SFWMD, 2002).

In contrast to the WSE schedule, the Supply-Side Management plan is used to manage lower stages in Lake Okeechobee. The SSM plan is a guideline for implementation of agricultural water shortage restrictions for the Lake Okeechobee Service Area under SFWMD Water Shortage Plan, as one of many tools in managing regional water resources during periods of shortage. The zone below the “SSM Trigger

Line" identifies when the district will consider imposing water shortage restrictions within the Lake Okeechobee Service Area. According to the current water shortage rule (Rules 40E-21 F.A.C. and 40E-22, F.A.C.), water restrictions may be declared on users of lake water when water levels within Lake Okeechobee fall below the "trigger line". A Phase I or Phase II restriction may be declared when Lake Okeechobee water levels can be expected to exceed or reach a June 1st lake stage of 10.5 feet NGVD, respectively. When water levels within Lake Okeechobee can be expected to fall below the June 1st lake stage of 10.5 feet NGVD, a Phase III or greater water shortage may be declared. Once a water shortage restriction is placed on agricultural users of lake water, allocation calculations associated with supply-side management will be performed on a weekly basis.

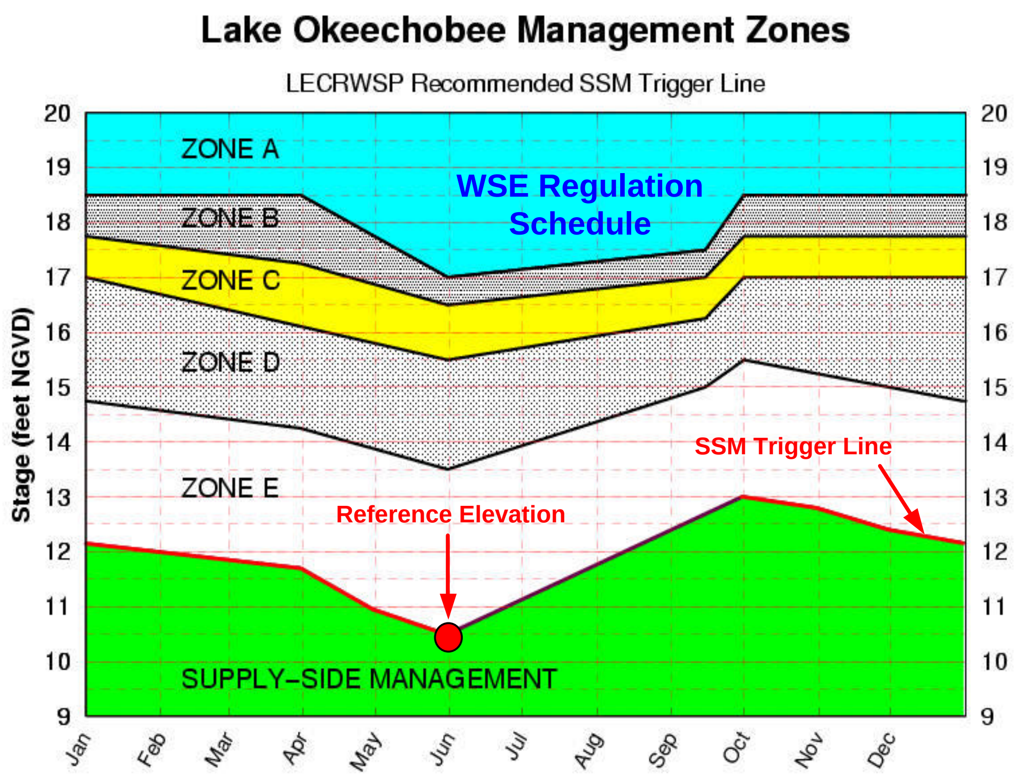

Figure 1 WSE Regulation and Supply Side Management Zones

Under the SSM methodology, the amount of water available to users of Lake Okeechobee water is defined as allocable volume and is a function of available storage within the lake in conjunction with expected net losses. The allocable volume of water is dependent on both expected climatic conditions and on a projected lake stage at the end of the dry season, known as the Reference Elevation (Figure 1). Temporal allocation of water under SSM is designed to avoid lake levels lower than the reference elevation at the end of the dry season, although this may not be prevented dependent on the severity of the drought. Under Phase I and Phase II water restrictions, the reference elevation is fixed at a level of 10.5 feet NGVD. However, under Phase III restrictions, a temporary revised reference elevation other than 10.5 ft. could be established. Water Shortage Rule 40E-21 and 40E-22, F.A.C. explain the details of conditions under which this may occur.

Minimum Flows and Levels criteria could also have a significant impact on Supply Side Management implementation. The SFWMD Minimum Flows and Levels rule (40E-8, F.A.C) states that water levels in Lake Okeechobee should not fall below 11 ft NGVD for more than 80 days duration, more often than once every six years, on average (SFWMD, 2000b). Obviously, when lake stages recede low enough to trigger use of the SSM Plan, the probability of experiencing MFL exceedances or violations increases. This type of impact must be considered when implementing SSM. In the future, other factors such as the construction of components of the Comprehensive Everglade Restoration Plan (CERP) structural components may also influence SSM implementation.

This document updates Supply Side Management 1991. It provides a complete account of the SSM procedure and addresses all assumptions and background information used in the method. First, information on Lake Okeechobee and its water budget components will be reviewed. Then, the Supply Side Management methodology and computational procedure will be outlined. Next, a discussion related to the information that will be used in examining possible changes to the reference elevation under Phase III restrictions will be provided. Finally, a sample calculation and summary are incorporated.

II. Lake Okeechobee

Lake Okeechobee (LOK) is the second largest fresh water lake in the United States. The lake has been diked around its borders and structures and gates have been constructed to regulate the flow of water to and from the lake (USACE and SFWMD, 1999). On the average, the water surface elevation in the lake is around 14.5 ft NGVD with a depth of about 9 feet. Extended dry periods in the recent past produced the record low stage of 8.97 ft NGVD on May 24, 2001. Managing low water levels require a good understanding of the major water budget components of Lake Okeechobee. In relation to supply-side management, these components are rainfall, evapotranspiration, tributary inflows and user demand.

Data used in the original SSM documentation (SSM1991) was based on historical records available at the time. In the updated methodology, input and output data from the South Florida Water Management Model (SFWMD, 1999) 31-year (1965-1995) base simulation run, referred to as 95BSRR, will be used during implementation. This run was used extensively in the Lower East Coast Regional Water Supply Plan (SFWMD, 2000). The SFWMM values to be used in the conjunction with the new methodology include rainfall and tributary inflows from model input (historical data pre-processed for input to the model) and evapotranspiration and supplemental user demands as simulated in the 95BSRR scenario. For information on the SFWMM please see Appendix A.

A. Precipitation

South Florida climate is primarily humid subtropical, with two seasons: the five-month rainy season from June through October, when 70% of the year's rain falls, and most hurricanes occur; and the seven-month dry season from November through May. In south and central Florida, average yearly rainfall is about 53 inches. However, "average" rainfall is rarely observed because actual rainfall varies widely from year to year and from location to location.

Using the 1965-1995 period of record, Lake Okeechobee has an average precipitation of 43 inches per year. Historically, precipitation in the lake is lowest in December (1.44 inches) and highest in June (6.46 inches). Figure 2 shows the average monthly distribution of rainfall for Lake Okeechobee.

B. Evapotranspiration

Average estimates of evaporation reported for Lake Okeechobee range from 49.5 inches to 57.8 per year (Abtew, 2001). The wide range of values is partly due to different evaporation estimation methods and is complicated by the existence of thousands of acres of isolated marshes (about 20% of the total lake surface area) that account for significant losses due to transpiration.

For the updated SSM, evapotranspiration (ET) in the lake is based on a modified Penman-Monteith method as implemented in the South Florida Water Management Model (SFWMD, 1999). ET in the lake does not vary as much as rainfall on a monthly basis. Figure 3 shows the average monthly distribution of evapotranspiration from Lake Okeechobee as a percentage of the annual total.

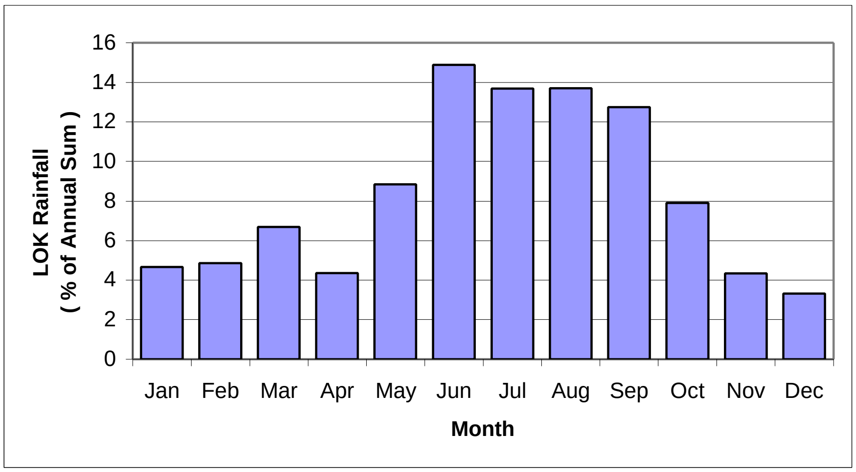

Figure 2. Monthly Average Rainfall in Lake Okeechobee

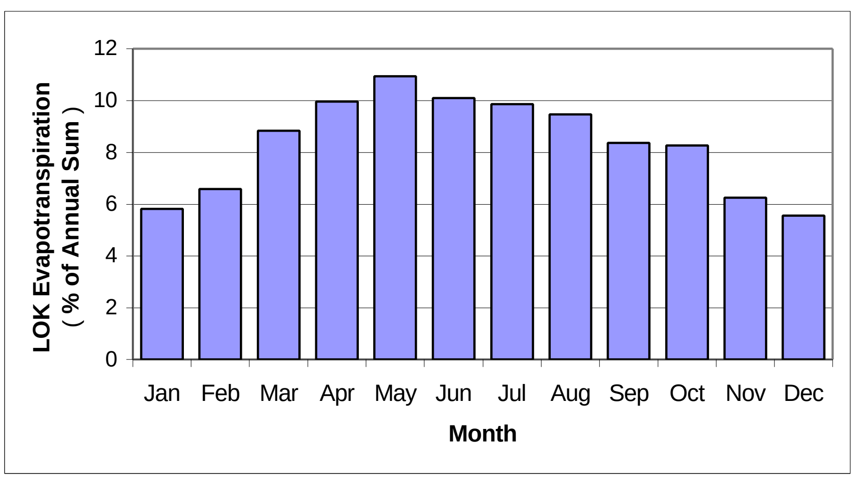

Figure 3. Monthly Average Evapotranspiration in Lake Okeechobee

C. Tributary Inflows

Tributary inflows to Lake Okeechobee primarily include runoff from Kissimmee River, Fisheating Creek, Taylor Creek, Nubbin Slough, and S-236 basins. SSM1991 does not account for these flows in calculating allocable water from Lake Okeechobee. Although conservative, exclusion of the tributary inflows can actually significantly underestimate the amount of water that will be available in the Lake (about 43 inches per year equivalent to direct rainfall based on the 95BSRR simulation). The updated SSM methodology incorporates tributary inflows in the calculations subject to drought forecasting, as will be explained later. Figure 4 shows the average monthly distribution of tributary inflows into Lake Okeechobee.

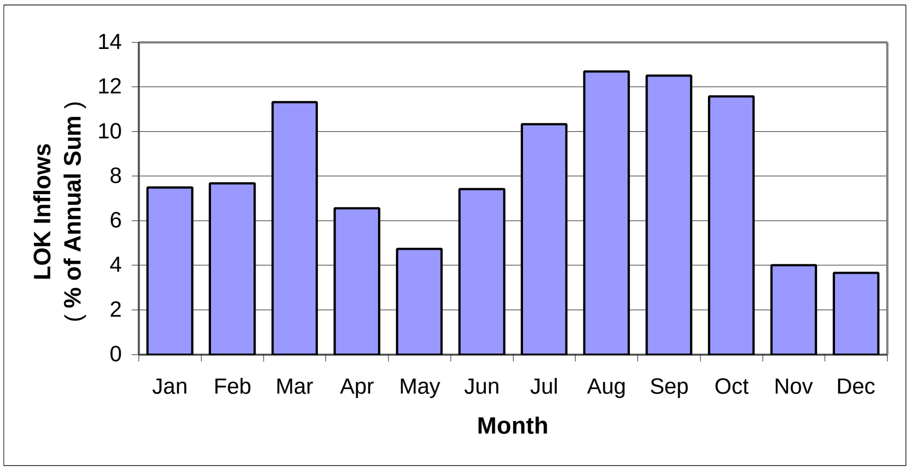

Figure 4. Monthly Average Tributary Inflows into Lake Okeechobee

D. Supplemental Demands on LOK

1. Agricultural Use

Lake Okeechobee is the primary source of supplemental irrigation for four major adjacent agricultural basins: North Shore, Caloosahatchee, St. Lucie and Everglades Agricultural Areas (Figure 5). Collectively, these basins are referred to as the Lake Okeechobee Service Area (LOSA). Principal crops include sugarcane and vegetables in the EAA and citrus and row crops in the Caloosahatchee and St. Lucie basins. During the dry season when precipitation is low, local sources of irrigation become scarce and the need for supplemental irrigation becomes absolutely necessary. With the current absence of substantial off-site storage, Lake Okeechobee is presently the only source of supplemental irrigation for these basins. Average annual supplemental irrigation requirement from Lake Okeechobee amounts to about half a million acre-feet (SFWMD, 2000a).

During droughts, i.e. below-normal precipitation events, higher than normal irrigation requirements exist as soil moisture levels are not maintained by local rainfall. Potential water shortage situations exist when high LOSA demand periods coincide with low Lake Okeechobee water levels. As a consequence, water must be “prudently budgeted, saved and distributed according to the needs during water shortage periods” (Hall, 1991). The average monthly distribution of LOSA supplemental irrigation demands on Lake Okeechobee as simulated in the 95BSRR is shown in Figure 6. Actual water deliveries are a function of hydrologic conditions, supply-side management, water resource protection needs, LEC water supply needs and conveyance limitations.

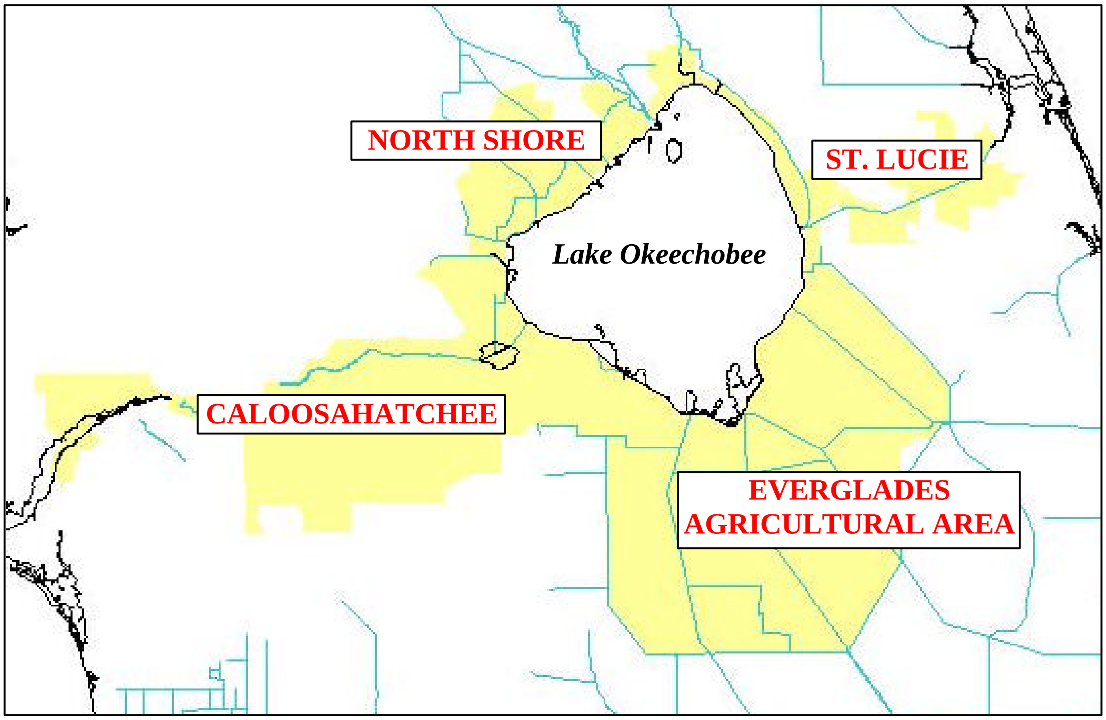

Figure 5. Lake Okeechobee Service Area Showing the North Shore, Caloosahatchee, St. Lucie and Everglades Agricultural Area Basins

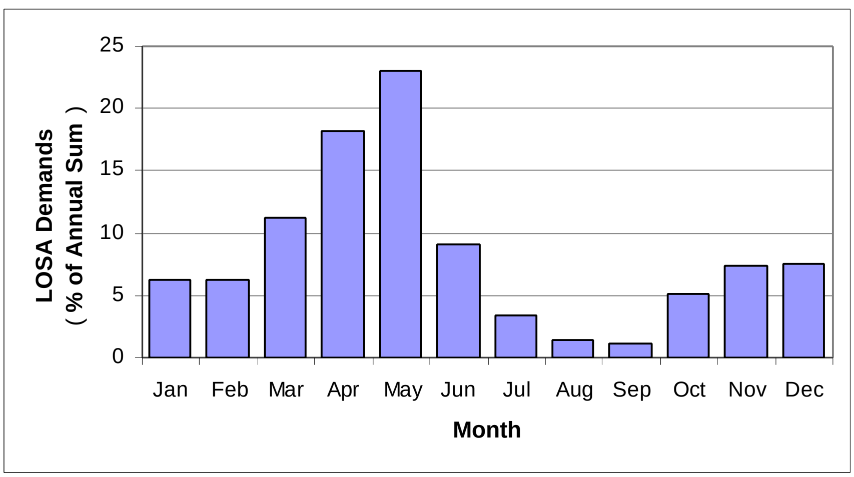

Figure 6. Monthly Average Supplemental Irrigation Demands from Lake Okeechobee

2. Urban Water Use and Prevention of Saltwater Intrusion

Urban use of Lake Okeechobee water is predominantly associated with deliveries to the Lower East Coast Service Areas (LECSAs). Surface water delivered to the LEC is used to maintain groundwater levels in the Biscayne Aquifer and to provide for water supply for commercial irrigation and public water supply users. A limited number of urban municipalities around Lake Okeechobee also depend on the lake for their domestic use. Lower East Coast canal levels are maintained at operational levels so as to maintain levels in the Biscayne Aquifer. The amount of water required to maintain coastal groundwater levels to prevent saltwater intrusion to counteract aspects of the drainage infrastructure far exceeds the amount of water needed to recharge urban wellfields. The hydraulic head created in the canals promotes seepage into the ground, providing recharge into the aquifer and urban wellfields. During the wet season, local rainfall and seepage from the Water Conservation Areas (WCAs) across the north-south protective levee system recharge groundwater levels. Conversely, during the dry season, the maintenance of these levels may be more dependent on deliveries from the regional system, particularly the Water Conservation Areas and then Lake Okeechobee. As pointed out by Hall (1991), the LEC urban users may only need to tap the lake as a secondary source of water every three to four years.

3. Entitlement for Seminole (Brighton & Big Cypress) Tribe

Pursuant to the Water Rights Compact (Pub. L. No. 100-228, 101 Stat. 1556, and Chapter 87-292, Laws of Florida, and codified in Section 285.165, F.S.) and implementing agreements, the Seminole Tribe of Florida has entitlement rights to surface water for its reservations. The Brighton Seminole Reservation northwest of the lake and the Big Cypress Seminole Reservation southwest of the EAA must be considered in addressing Lake Okeechobee supply side management. Cutbacks associated with the Water Shortage Plan and supply-side management may apply to the Tribe's water rights in accordance with the Water Rights Compact and the controlling agreements.

4. Maintenance of Navigation Depths / Lockages outside of Lake Okeechobee

In order to maintain minimum navigation depths, the USACE can release water into the Caloosahatchee River & the St. Lucie Canal. While the Water Shortage Plan outlines the process by which the District may request that the USACE limit lockages based on water availability, these releases, even when being limited, can still account for large volumes of water over the course on an entire dry season. In fact, during the 2000-2001 dry season, approximately 40,000 ac-ft of water were released for this purpose. Additionally, water can flow out of Lake Okeechobee due to the operation of the several locks located around the perimeter of the lake.

5. L-8 Basin Deliveries

Drinking water supply for the city of West Palm Beach comes from Lake Mangonia and Clear Lake that are recharged by the city’s 20-square-mile water catchment area via the M-Canal. Water from Lake Okeechobee via S-352, C-10A, S-5AS and the L-8 Canal may be used to augment water supply deliveries from the catchment area. The LECRWSP 95BSRR simulation estimates these deliveries at 22.2 kaf/yr during the dry season.

6. Water Supply Deliveries to STAs

The Stormwater Treatment Areas (STAs) under the Everglades Construction Project are large constructed wetlands designed to reduce phosphorus concentrations in stormwater originating from EAA, C-139 and C-51 West basins; and Lake Okeechobee releases prior to discharging treated into the Water Conservation Areas. The long-term phosphorus removal mechanism for the STAs is the growth and subsequent deposition of organic matter as new sediment –in short, accumulation of peat. To ensure that the organic sediment does not release phosphorus upon exposure to the air, the operational target for the STAs is to maintain a minimum depth of 6 inches. The potential impacts of dryout within the STAs will vary depending on site-specific soil, vegetation and hydrology, and include the death of wetland vegetation due to dehydration, the growth of undesirable vegetation (exotics, dog fennel, and other terrestrial species), a flush of phosphorus upon rewetting, and potentially a year or more off-line as the vegetation regrows before the treatment cell once again produces a net reduction in phosphorus. In addition, there is evidence to suggest that dry out and subsequent rewetting of these systems may exacerbate the mercury methylation process, which in turn may induce potential risks to wildlife on-site and in the downstream Everglades.

In addition to the biological basis for maintaining minimum depths within the STAs, there are relevant legal and regulatory concerns. The District is party to a federal Everglades Settlement Agreement that establishes performance targets for the STAs. To the extent that dry downs adversely affect the STAs ability to achieve the target performance, there may be legal consequences. Additionally, the STAs are subject to both state and federal operation permits that establish minimum performance targets and operational requirements to ensure those performance targets are met. Non-compliance may result in enforcement action against the District. It is expected that the amount of Lake Okeechobee water needed to maintain all STAs will be very minimal relative to the other water deliveries from Lake Okeechobee.

7. Environmental Needs and in the Caloosahatchee & St. Lucie Estuaries

Change in storage in Lake Okeechobee may be influenced by environmental releases to the Caloosahatchee and St. Lucie estuaries. A limited range of freshwater discharges into these estuaries may be considered environmentally beneficial to the sensitive ecosystems they support. It is important to maintain some base flows to these estuaries during dry periods. Chamberlain et al. (1995) reported salinities greater than 50 percent seawater (17 ppt) within the upper Caloosahatchee Estuary during prolonged low flow conditions. Likewise, high salinity conditions, up to 80 percent of seawater (28 ppt), occur periodically in the St. Lucie Estuary. These high salinity conditions result in stress to estuarine organisms and reduction of their populations due to increased predation and parasites. District staff are continuing efforts to develop science-based minimum (dry season, low) flow criteria for the Caloosahatchee and St. Lucie estuaries. Two related District projects, the Caloosahatchee Water Management Plan and the Indian River Lagoon Plan, may provide guidelines on the amount, timing and distribution of Lake Okeechobee releases necessary to meet the minimum estuarine demands for the Caloosahatchee and St. Lucie estuaries.

Overall, the impact of salinity control in both estuaries on SSM may or may not be evaluated depending on how policy decisions are made in the future. Currently, it is expected that the Lake Okeechobee Adaptive Protocols (SFWMD, 2002) will provide more definition on the nature and timing of such releases. Additionally, it is important to note that some public water supply deliveries may be made (e.g. to reduce salinity at the Ft. Myers water treatment plant intakes) that could provide a benefit to the estuaries during periods of water shortage.

8. Minimum Delivery Schedule for Lake Istokpoga

Estimates of the Lower Lake Istokpoga basin non-Tribal agricultural demands amount to 13.2 kaf/yr as simulated in the LEC 95BSRR. Lake Okeechobee water is pumped via G-207 & G-208 to maintain canal levels downstream of S-71 and S-72 on the C-41 and C-40 canals, respectively. The delivery schedule may or may not be subject to supply-side management depending on the water shortage conditions for Lake Istokpoga and the Indian Prairie Basin, which comprise the reaches upstream of S-71 and S-72.

9. Freeze Protection

During periods of near freezing temperatures, the South Florida Water Management District may make short-term water supply releases from Lake Okeechobee into LOSA to allow for the protection of crops from damage due to freezing. The specific quantities, destinations and duration of releases would be highly variable depending on the severity and location of the specific event.

E. In-Lake Water Demands

1. Environmental Health of Lake Okeechobee

While the demands outlined in Section II.D are related to specific volumes of water required for withdrawal from Lake Okeechobee, there exist demands for water within the Lake itself. These demands are not so much related to a specific volume required at a designated delivery time as they are to the magnitude and duration of low stage levels in the Lake. Due to the relationship of this type of in-Lake demand to stage rather than volume release, the SSM methodology will consider this demand when establishing temporary reference elevations with consideration for MFL and marsh exposure criteria as will be discussed later (Section III.C).

2. Navigation and Recreational Uses on Lake Okeechobee

As is the case with the environmental health of the Lake, the impacts of drought conditions to navigation on Lake Okeechobee (and associated recreational industries such as tourism and fishing) are more evident when examining lake stage rather than a specific volume of release. Navigation within Lake Okeechobee and its perimeter canal are significantly impacted when the Lake falls below an elevation of 10.5 ft. NGVD (the reference elevation for Phase I and Phase II drought declarations). This demand will be considered as part of any temporary reference elevation adjustments (Section III.C).

III. Supply Side Management Methodology

A. Historical Use

The original assumptions of Supply Side Management were: 1) the minimum lake stage at the end of the dry season should not be allowed to fall below 11.0 ft NGVD; 2) for computational purposes normal rainfall, normal evaporation and normal agricultural water use demands would be utilized; and 3) a stage of 13.5 ft NGVD at the beginning of the dry season (October 1) is the level which must be exceeded in order to defer implementation of supply-side management calculations. A provision for early use of allocation, “borrowing”, was incorporated at the time as a means of managing short-term fluctuations in demand. A major reason for borrowing, especially during the earlier growth stages of sugarcane (sugarcane requires less water during harvest time), was to maintain yields.

After being invoked in 1982, 1985 and 1989, the Water Shortage Plan was subsequently updated in 1991(SFWMD, 1991). Under SSM1991, water allocations to agricultural users in the LOSA are progressively cutback as shortage become more severe. SSM1991 assumes that up to 327,000 acre-feet of water may be needed for the Lower East Coast Service Areas, which is the equivalent storage in Lake Okeechobee between 11 and 10 ft NGVD. The need for drought management measures outside of the SSM computational procedure was also realized in the updated Water Shortage Plan. This is evident since the plan states that the SFWMD Governing Board would decide during its monthly meetings or special sessions on “additional steps necessary to manage available supplies during the shortage”.

SSM was used as a component of the Lower East Coast Regional Water Supply Plan in 2000. During the development process of the water supply plan, modifications were once again made to the SSM methodology. The line used to trigger SSM implementation was lowered by half a foot relative to the original line presented in SSM1991. Additionally, the "target stage" (reference elevation) was lowered from 11.0 to 10.5 ft NGVD. During the 2000 drought, SSM was applied as a tool to calculate allocations for agricultural users in LOSA. Due to low lake level at the beginning of the 2000-2001 dry season and the extreme severity of drought conditions in Lake Okeechobee, the District's Drought Management Team, with oversight by the Governing Board, had to make several changes to the recommended reference elevation in order to account for the greater then normal losses from evapotranspiration, to adjust for deliveries to non-agricultural users of Lake water, and to provide a minimum level of service to agricultural users of lake water (approximately 50% of their demand). In the process of managing this record-setting drought, a better understanding of the system was observed and the need to make improvements to the computational elements of supply-side management was realized.

B. SSM Calculation Procedure

The “SSM trigger line” with a 13.0-to-10.5 ft NGVD beginning-to-ending stage based on the Lower East Coast Regional Water Supply (LECRWS) Plan (Figure 1) will be considered in determining when a water restriction will be declared in LOSA and supply side management should be implemented. While SSM1991 only explicitly addresses the demands of LOSA agriculture and the LEC, the updated Supply Side Management methodology attempts to quantify and manage the demands of additional Lake Okeechobee water users (as defined in the LECRWSP, SFWMD 2000a) in the computational procedure. In the method, this goal is accomplished by working with share accounts, which break down allocable volume into individually maintained ledgers that quantify the amount of water available in Lake Okeechobee for each user during the dry season. These account volumes are by no means entitlements for particular users to specified volumes of water, but rather are a representation of the *predicted* volumes of water available to users (as calculated by the SSM computational procedure). Any "balance" of water in a share account is still considered a shared resource and is subject to management as deemed appropriate by the District's Drought Management Team.

Once SSM implementation begins, three general steps will be followed on a weekly basis to calculate user allocations. These steps are:

1) Calculate LOK allocable volume - How much water is available for use in LOK between now and the end of the dry season?
2) Distribute allocable water among users - How much of the allocable water is available for each specific user?
3) Manage share accounts - How much of a demand for water does a user have for this week relative to the remainder of the dry season? How much volume is remaining for that user for the remainder of the dry season?

Each of these steps is outlined in detail in the subsequent sections. The SSM computational procedure can be represented graphically as a weekly cycle as shown in Figure 7.

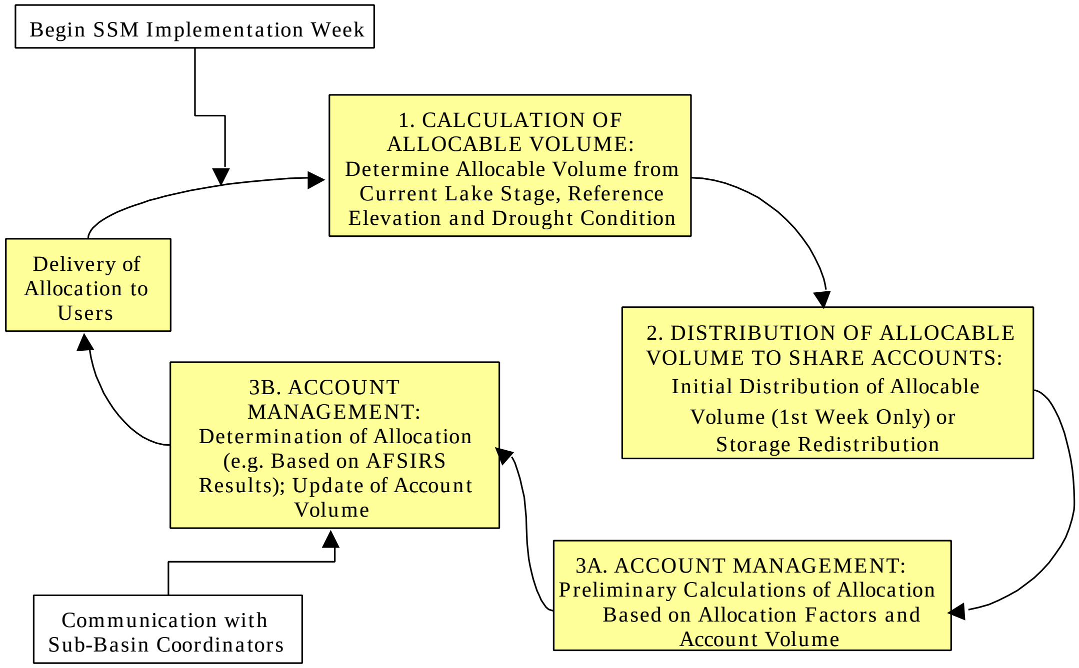

Figure 7. SSM weekly computational cycle.

1. Calculation of Allocable Volume of Water

Allocable volume of water at any point within the dry season can be calculated as the arithmetic sum of available storage in Lake Okeechobee plus expected net lake storage change for the remainder of the dry season (1). Available storage (2) is the instantaneous storage in the lake calculated as the difference between lake storage corresponding to the current stage and lake storage at a predetermined reference elevation (See Section III.C for more information on reference elevation determination). Expected net storage change was defined in SSM1991 as the difference between the “normal” or average rainfall and “normal” or average evaporation on Lake Okeechobee for the remainder of the dry season. The updated SSM methodology extends this definition to include a third component: runoff from Lake Okeechobee tributary basins or tributary inflows. As such, net storage change will now be referred to as net inflow. This approach represents a more accurate depiction of the Lake Okeechobee water budget compared to the previous approach.

$$\text{Allocable Volume} = \text{Available Storage} + \text{Net Inflow} \quad (1)$$

$$\text{Available Storage} = \text{LOK Storage (current)} - \text{LOK Storage (at reference elevation)} \quad (2)$$

In addition to including tributary inflows, the updated SSM methodology more accurately predicts net inflow for the remainder of the dry season by monitoring the current state of the climate and its outlook. While SSM1991 always assumes that normal rainfall and evapotranspiration will persist for the remainder of the dry season, a better estimate of the net inflow portion of the allocable water can be made based on existing drought condition. The rationale behind using the drought condition is to associate different drought severities with return frequencies. Initially, the U.S. Drought Monitor has been selected as the tool for selecting the current drought condition. The Drought Monitor (available on the Internet at http://www.drought.unl.edu/dm/index.html) is a synthesis of multiple indices, outlooks and news accounts, that represents a consensus of federal (CPC, NOAA, etc.) and academic (National Drought Mitigation Center) scientists. It classifies regions of the United States into one of five drought categories ranging from "abnormally dry" to "exceptional drought". Once the drought condition is known, the corresponding return frequency can be cross-referenced from the values recommended in Table 1. Then, the cumulative-to-end of dry season estimates of net inflow (RF-ET+TribInflow) for different drought conditions can be extracted for the appropriate week in Table 2. Once this expected net storage change term is known, allocable volume can be calculated.

As a means of preventing large fluctuations in allocable storage from week to week, it is proposed that if a change is observed in the Drought Monitor from one week to the next, the expected net storage change condition (which affects the allocable volume) should not be immediately updated. Rather, the new condition in the Drought Monitor should persist for at least three weeks prior to making an adjustment to the expected net storage change condition.

Table 1. Range of Drought Monitor Classifications and Corresponding Return Frequencies

Drought Monitor	**Condition**	**Return Frequency**
No Drought Indication	Normal	1-in-2
D0	Abnormally Dry	1-in-3
D1	Moderate Drought	1-in-5
D2, D3 or D4	Severe Drought	1-in-10

2. Distribution of Allocable Water to Share Accounts

There are two types of accounts associated with the updated Supply Side Management methodology. Type I accounts will be established for those users whose account volumes will be affected by changes in LOK allocable storage while Type II accounts will be established for those users whose account volumes will not be not affected by changes in LOK allocable storage. Most of the users of Lake Okeechobee water fall under the category of Type I accounts. In these accounts, the amount of water available to users is dependent on conditions within the Lake Okeechobee and will fluctuate weekly depending on climatic conditions and lake stage as outlined in Section III.B.2.b. Type II accounts, on the other hand, are managed independently of changes in overall allocable volume and the only changes in account volumes occur when allocations or deliveries are made. Examples of Type II accounts would be an account that manages the water allocations to meet Seminole tribal demands or an account that delivers water to the St. Lucie Canal for maintenance of navigation depths. These type of entitlement allocations or USACE controlled deliveries are made outside of a Supply Side Management allocation scheme and as such are treated differently in the SSM methodology. It is assumed that such deliveries are cut back during drought and already represent a reduced volume. The instantaneous cumulative sum of all account balances in both Type I and Type II accounts will equal the allocable volume in Lake Okeechobee.

Table 2. Cumulative Net Inflow (RF-ET+TribInflows) from Current Week to End of Dry Season (ac-ft)

Dry Season Week	Severe Drought (1 in 10)	Moderate Drought (1 in 5)	Abnormally Dry (1 in 3)	Normal (1 in 2)
1	-739795	-456011	-198719	-38062
2	-777872	-541301	-274154	-30724
3	-774432	-593794	-256453	-31011
4	-769722	-582844	-270630	-47761
5	-752147	-586565	-243061	-44575
6	-746291	-561985	-198755	-19364
7	-702162	-517164	-179439	-7231
8	-663093	-483120	-160517	10957
9	-628861	-444150	-154788	51604
10	-618213	-447831	-140197	52516
11	-596260	-411440	-127369	72750
12	-568495	-418201	-95770	97887
13	-562216	-401904	-70415	124496
14	-549836	-386878	-56828	112285
15	-597912	-372759	-67645	119568
16	-544509	-346805	-64041	110167
17	-532635	-321617	-87280	102177
18	-497534	-297430	-93826	59212
19	-499005	-270269	-108317	28553
20	-386864	-218701	-144836	43485
21	-402229	-199978	-151686	60333
22	-418626	-222760	-130599	14279
23	-407605	-208299	-168370	-9376
24	-342763	-224983	-163679	-73087
25	-333928	-263842	-153348	-57160
26	-290553	-264191	-114449	-23650
27	-284331	-230383	-114721	-62254
28	-246615	-166744	-116380	-43949
29	-218036	-163947	-113275	-55752
30	-187203	-156316	-104994	-58043
31	-143707	-126237	-103058	-35528
32	-126180	-104453	-52529	-27129
33	-83700	-71824	-43209	-10554
34	-61949	-51824	-35262	-20223
35	-47433	-38463	-22464	-3797

a. Initial Distribution of Allocable Volume

When Supply Side Management is first implemented, it is necessary to calculate allocable volume in Lake Okeechobee and then distribute this volume into share accounts prior to calculating allocations. The District's Drought Management Team will assess the projected demands on Lake Okeechobee and determine how many share accounts to establish. As a minimum, it is suggested that there be an account for LOSA (a combined account for all sub-basins as identified in Figure 8 and detailed in Table 3), an account for the LEC service areas and L-8 basin as a whole, an account for Seminole Tribal entitlements and an "Others" account that groups smaller users (e.g. STA deliveries, navigation releases) into one ledger. Under this scenario, the LOSA account and the LEC account would be Type I accounts while the Tribal account and the "Other" account would be Type II.

A demand-based strategy will be used to distribute allocable storage to share accounts. As a first step, the District's Drought Management Team would quantify based on the best available projections of demand (including appropriate cutbacks) or compact agreements the volume required by each of the Type II users. These volumes would then be placed into the specific Type II share accounts. The remainder of the allocable volume would then be partitioned to LOSA, the LEC and any other Type I account based on that user's fraction of the total projected demand. For example, if LOSA were to have a projected demand of 200,000 ac-ft and the LEC was projected to have a demand of 50,000 ac-ft, then the LOSA account would receive 80% or 200,000 / (200,000 + 50,000) of the remaining allocable volume and the LEC would receive 20%. As a reference, Tables 4 and 5 provide cumulative to the end of dry season demands under different drought conditions for LOSA and the LEC as extracted from the SFWMM 95BSRR simulation.

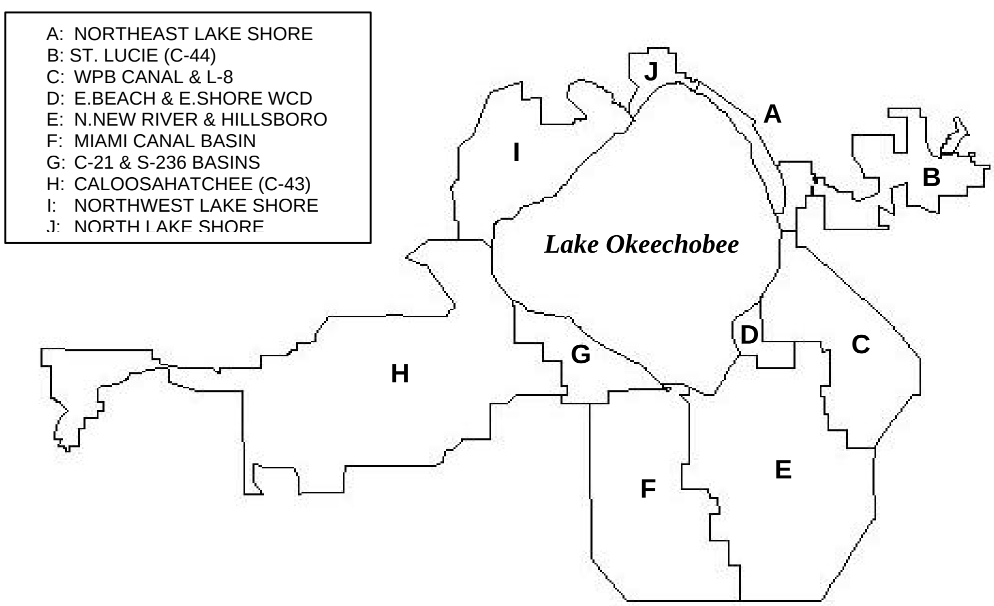

Figure 8. Identification of Lake Okeechobee Service Area Sub-basin Boundaries

Table 3. Lake Okeechobee Service Area Sub-basins

Sub-Basin Name	**Crop Type**	**Controlled by Structure(s)**	**Water Use Permit Irrigated Area (ac)***
NORTHEAST LAKE SHORE	Citrus	S-135 & G-36	420
	Other		7,289
ST. LUCIE (C-44)	Citrus	S-308	47,575
	Other		8,776
WPB CANAL & L-8	Citrus	S-352, C10A, C13 & C16	7,590
	Other		123,537
E.BEACH & E.SHORE WCD	Citrus	C-12 & C-10	0
	Other		13,054
N.NEW RIVER & HILLSBORO	Citrus	S-351 & C-4A	234
	Other		230,146
MIAMI CANAL BASIN	Citrus	S-354	2,426
	Other		113,325
C-21 & S-236 BASINS	Citrus	S-310 & S-169	0
	Other		34,122
CALOOSAHATCHEE (C-43)	Citrus	S-77 & C-5A	68,219
	Other		58,311
NORTHWEST LAKE SHORE	Citrus	S131,S129,S127, G207,G208	4,362
	Other		2,101
NORTH LAKE SHORE	Citrus	S-193	117
	Other		1,060

Total: 722, 664 acres

* As of October 2001

b. Storage Redistribution

As the dry season progresses, actual climatic conditions will inevitably vary from those assumed in the "expected net losses" portion of the SSM allocable volume calculation. In order to keep the cumulative balance in the share accounts equal to the total amount of allocable water in Lake Okeechobee, it is necessary to perform a "storage redistribution" for every week after the initial week of SSM implementation. This storage redistribution essentially takes any gain or loss in lake storage on a weekly time step (outside of user allocations or deliveries) and disperses this volume into the Type I share accounts. Equation 3 illustrates the procedure for a given implementation week (week *i*). Since by definition Type II account balances can not be affected by changes in Lake Okeechobee allocable volume (e.g. due to their entitlement nature), these accounts are not affected by the storage redistribution. The amount of volume to be redistributed for a given week is equal to the current week's allocable volume minus the previous week's allocable volume minus the total withdrawn from ALL accounts during the previous week. Withdrawals (as defined in Section III.B.3) from all accounts must be considered because Type II accounts are part of the LOK water budget even thought they are not affected by the storage redistribution. Once the redistribution volume is known, it is partitioned into the share accounts in the same remaining demand-based manner as was used in the initial distribution to Type I accounts.

$$(\text{Storage Redistribution})_i = (\text{Allocable Volume})_i - (\text{Allocable Volume})_{i-1} - \Sigma\,(\text{User Withdrawals from ALL Accounts*})_{i-1} \qquad (3)$$

*By sign convention, this value should be negative since water is leaving LOK.

Since storage redistribution can be either positive or negative, users of lake water will both be rewarded with increased volume during wetter periods and be cutback further as their account volume is depleted during drier periods. Adjustments to the reference elevation from one week to the next (under Phase III restrictions only) will be handled as part of the storage redistribution. In fact, the computation already accounts for the change in storage resulting from the an adjustment since the current week's allocable volume is dependent on the revised reference elevation.

3. Account Management

Three events can affect volumes within share accounts: 1) changes in LOK allocable storage (Type I only), 2) water use "withdrawals" in the form of an allocation or a delivery, and 3) account transfers. The first of these has already been outlined in the previous section. The second and third items will now be addressed. In the case of LOSA agriculture, water use is based on an allocation scheme in which users are only allowed to use a volume of water as set by the SFWMD and associated with the SSM computational procedure. In a similar manner, tribal entitlements (although they are pre-determined) are treated as allocation volumes on a week to week basis. On the other hand, several users of lake water, do not necessarily consume water based on an allocation scheme. This is the case with releases made for maintenance of navigation levels in the St. Lucie Canal and Caloosahatchee River where water is released to maintain certain downstream stage levels are reached. The best way to manage these accounts is to keep track of estimated deliveries (possibly with a one to two week delay due to data collection / reporting constraints) as opposed to allocations. In either event, water "withdrawn", defined as allocation or delivery as deemed appropriate by the District's Drought Management Team, will be deducted from the appropriate account at the end of an implementation week. The District's Drought Management Team will keep track of the volume in the share accounts as is appropriate to the use type. The specific computational procedure for determining LOSA allocations is presented in the next two sub-sections. Information about the third item that can affect account volume, transfers, is presented in part c.

a. Preliminary Calculations for LOSA

During an implementation week, once the LOSA account volume for the remainder of the dry season is determined, it is necessary to know how that volume is distributed in time. A logical way to initially distribute the allocable volume is to pattern it according to the distribution of the expected or anticipated LOSA demands for the dry season. This definition makes use of the concept of allocation factor, which is documented in the SSM1991. Using frequency analysis and linear regression techniques, the allocation factors can be derived so as to represent a weekly multiplier for the corresponding allocable volumes. The allocation factors exhibit some important features. They are computed only once, i.e., at the beginning of the dry season. Values increase towards the end of the dry season and the allocation factor for the last week of the dry season is always equal to one. Table 6 shows the allocation factors for the dry season based on LOSA demands for different return frequencies. This table represents how demands can be distributed over time given the corresponding allocation factor time series. For a particular week within the dry season (week *i*), the account volume multiplied by the allocation factor gives the preliminary allocation for the week for that user (Equation 4).

$$(\text{Preliminary Allocation})_i = (\text{Account Volume})_i * (\text{Allocation Factor})_i \qquad (4)$$

b. Determination of Allocation for LOSA

While the preliminary allocation calculation provides a guideline volume for agricultural weekly demand, ambient conditions may result in either greater or less demand than that initially calculated. Under SSM1991, the calculated allocation would be the volume available to an agricultural user for the given week. While there was a "borrowing" option in SSM1991 for weeks early in the dry season, in general there was no specific way to adjust allocation volumes to handle short-term fluctuations in demand. The updated SSM methodology will correct this by providing users the flexibility to deviate from the calculated allocations. If wetter conditions exist LOSA does not have a need (as expressed by the sub-basin coordinators to the SFWMD) for supplemental irrigation, it is beneficial to request no allocation and preserve water in the account for later dry periods. On the other hand, if extremely dry conditions exist, users may require more irrigation than the volume dictated by the preliminary calculation. In this event, LOSA may request an allocation volume for that week up to their portion of 50% of the weekly estimated 1-in-10 like demand condition (Table 7). It is important to note that requesting higher allocation volumes reduces the volume left in the share account more rapidly than does using the allocation dictated by the allocation factors. This may result in a user having less water available in future weeks. In other words, if a user decides to take a significant portion of the volume in their account early in the dry season, that user could be penalized later in the dry season if drought conditions continue and their account volume has already been depleted.

In order to help determine the real-time level of demand for LOSA agricultural users it is proposed that the Agricultural Field-Scale Irrigation Requirement Simulation (AFSIRS) model developed at the Agricultural Engineering Department of the University of Florida be used. AFSIRS (Smajstrla, 1990) is a crop root zone water budget computer model that predicts water requirements for maximum crop yields. It calculates the amount and frequency of irrigation necessary to avoid water stress to crops. Primary input data to the computer model are crop type, irrigation method and soil type. Climatological time series data in terms of rainfall and potential evapotranspiration are also required input to the model. The model calculates irrigation requirements and actual evapotranspiration rates as a function of the input data for each time step in a simulation. Output is provided for irrigation and evapotranspiration in units of depth per acre of irrigated area. The benefit of using AFSIRS in the method is that it can be adapted to give an indication of real-time demand whereas other methods, such as Blaney-Criddle, do not provide good estimates of real-time demand.

At the beginning of each allocation period (week), AFSIRS is run for the predominant crop types (e.g. citrus and sugar cane) on a daily time step for all 10 LOSA sub-basins. Daily rainfall, up to the end of the previous allocation period, is collected for the 10 sub-basins based on 55 stations (Figure 9). A combination of radar data and Thiessen weighted average values are used to calculate rainfall for each of the 10 sub-basins. Daily potential evapotranspiration is calculated using a temperature-based approximation to the Penman-Monteith method. Seven climatological stations are used to compute evapotranspiration from the 10 LOSA sub-basins (Figure 10). The weather station assignments to the LOSA sub-basins are given in Table 8.

Table 4. LOSA Cumulative Demands to End of Dry Season for Different Drought Conditions (ac-ft)

Dry Season Week	Severe Drought (1 in 10)	Moderate Drought (1 in 5)	Abnormally Dry (1 in 3)	Normal (1 in 2)
1	786016	654115	550296	463016
2	775441	651414	544150	457521
3	755809	634436	534334	455403
4	731267	602870	523489	449138
5	722890	583732	520283	441853
6	711455	566969	509680	434475
7	691303	551427	487118	426617
8	686619	531341	470928	417824
9	683360	520727	460029	409728
10	681120	515053	449004	396330
11	671561	498905	438961	390927
12	652682	479282	431939	376924
13	647002	460185	423205	361474
14	627836	449857	421985	354541
15	606293	438736	411280	351598
16	586945	423518	391845	350861
17	572652	420257	371968	346285
18	565839	413196	364209	336759
19	543512	399194	361355	328010
20	531341	378209	346257	315510
21	526700	360630	333728	308010
22	509881	352062	323431	305849
23	494305	338087	311642	297158
24	471507	330353	308091	287378
25	445294	322411	299382	269341
26	406455	301295	288124	263220
27	369004	299788	269355	231639
28	337537	299761	260281	209965
29	303455	285479	240378	183808
30	291133	252632	219407	172320
31	260452	217036	180264	146161
32	205585	179440	136905	114367
33	155192	135089	99058	82939
34	96703	81841	58504	40450
35	58494	39665	27473	13027

Table 5. LEC Cumulative Demands to End of Dry Season for Different Drought Conditions (ac-ft)

Dry Season Week	Severe Drought (1 in 10)	Moderate Drought (1 in 5)	Abnormally Dry (1 in 3)	Normal (1 in 2)
1	144552	106651	59334	39648
2	144552	106651	59334	39329
3	144552	106651	59334	39329
4	144552	106651	59334	39329
5	144552	106651	58644	39329
6	144552	106651	58196	39329
7	144552	106597	58196	39329
8	144552	105732	58196	39291
9	144552	104515	57738	39291
10	144552	103648	56161	39291
11	144552	102154	54977	38633
12	144454	99383	54977	37294
13	144177	97102	54977	34894
14	143881	94793	54977	30461
15	143391	92354	54975	28382
16	141370	89995	54975	28382
17	141112	87946	54975	28382
18	140870	85961	54975	27352
19	140606	83969	54975	26137
20	140343	82238	54975	25819
21	131498	80528	54975	25819
22	126944	79193	54975	25167
23	126698	76829	54975	23943
24	124659	73019	54394	23423
25	120057	68222	52648	22975
26	114894	64839	50052	21202
27	108089	60566	47424	18903
28	90055	56851	40624	17425
29	76662	54657	32385	16413
30	63133	51333	28392	14249
31	51049	44900	21110	12460
32	42582	34319	18603	10987
33	29961	28342	12792	8230
34	20069	16090	8620	5346
35	10711	5960	3521	1220

After the AFSIRS model is run, irrigation requirements (inch per acre) for the allocation period are available for the predominant crop types in each sub-basin. AFSIRS model output can be used to assess which users have a greater demand for water and which users do not necessarily need an allocation for the implementation week. The advantage of this approach is that soil moisture deficit accounting can be made on a “real-time” basis using a well-documented field-scale model. Once an indication of real-time demand is known, the District's Drought Management Team will communicate with the sub-basin coordinators and then will determine what the allocation volume (ranging from 0 ac-ft to 50% of the 1-in-10 like demand) will be for the implementation week. This is the volume that will be "withdrawn" (deducted) from the LOSA account and will be used in calculating the storage redistribution at the start of the next implementation week. As previously stated, Type I accounts other than LOSA agriculture and Type II accounts will be managed by the District's Drought Management Team as is appropriate to the use type.

c. Transfers

Another tool available to the District's Drought Management Team that can be used to affect volume in accounts is the use of transfers. When a condition exists in which a particular share account has what is deemed to be a disproportionate share of water (given that user's projected demand), the District Drought Management Team can choose to transfer water out of that account into other users who may be under more severe drought conditions. Obviously, this tool will not be used arbitrarily to even the level of cutback across users. The use of account transfers, rather, is meant to allow flexibility under changing drought conditions to weigh the needs of various users and distribute allocable water in an equitable way. Consideration will be taken in making transfers to assure that those users who have judiciously reserved water in their accounts by taking smaller allocations will not be penalized later in the dry season with a transfer withdrawal that leaves them a significantly reduced account volume. An example of a transfer scenario would be one in which significant rain falls on the Lower East Coast and there is no longer a projected need to make deliveries out of Lake Okeechobee to the LEC Service Areas for the remainder of the dry season. In this type of scenario, water previously held in the LEC account could be transferred into the LOSA account of users who may still be under severe cutbacks, thereby increasing their allocable volume and averting the need for a possible change to the reference elevation.

Table 6. SSM LOSA Allocation Factors for Different Drought Conditions

Dry Season Week	Severe Drought (1 in 10)	Moderate Drought (1 in 5)	Abnormally Dry (1 in 3)	Normal (1 in 2)
1	0.0125250	0.0070221	0.0000000	0.0000000
2	0.0182138	0.0140112	0.0050531	0.0032728
3	0.0255450	0.0211468	0.0097344	0.0077824
4	0.0241215	0.0227714	0.0138565	0.0112527
5	0.0238883	0.0240190	0.0174240	0.0140365
6	0.0245411	0.0252223	0.0204314	0.0163517
7	0.0247973	0.0257234	0.0228689	0.0183193
8	0.0248003	0.0259478	0.0247278	0.0199910
9	0.0246590	0.0259114	0.0260069	0.0213712
10	0.0244554	0.0257017	0.0267192	0.0224356
11	0.0242507	0.0253794	0.0268979	0.0231486
12	0.0240928	0.0249886	0.0266035	0.0234787
13	0.0240220	0.0245680	0.0259286	0.0234144
14	0.0240778	0.0241602	0.0250006	0.0229779
15	0.0243046	0.0238215	0.0239824	0.0222382
16	0.0247569	0.0236286	0.0230693	0.0213203
17	0.0255039	0.0236851	0.0224828	0.0204097
18	0.0266340	0.0241249	0.0224623	0.0197520
19	0.0282574	0.0251141	0.0232571	0.0196459
20	0.0305097	0.0268519	0.0251198	0.0204318
21	0.0335549	0.0295700	0.0283030	0.0224797
22	0.0375905	0.0335346	0.0330629	0.0261794
23	0.0428540	0.0390508	0.0396694	0.0319398
24	0.0496351	0.0464736	0.0484257	0.0401994
25	0.0582955	0.0562298	0.0596990	0.0514558
26	0.0693024	0.0688551	0.0739675	0.0663184
27	0.0832845	0.0850590	0.0918927	0.0855956
28	0.1011313	0.1058343	0.1144356	0.1104381
29	0.1241722	0.1326512	0.1430564	0.1425829
30	0.1545289	0.1678236	0.1800843	0.1847966
31	0.1958705	0.2152609	0.2294674	0.2417479
32	0.2552585	0.2822158	0.2984888	0.3218954
33	0.3485770	0.3841260	0.4024116	0.4420529
34	0.5219288	0.5624432	0.5809834	0.6397856
35	1.0000000	1.0000000	1.0000000	1.0000000

Table 7. LOSA Weekly 1-in-10 Demand Volumes (ac-ft)

Dry Season Week	1-in-10 Weekly Demand Volumes for LOSA
1	13204
2	18961
3	26108
4	24023
5	23217
6	23282
7	22948
8	22381
9	21702
10	20992
11	20307
12	19686
13	19155
14	18738
15	18459
16	18346
17	18432
18	18757
19	19371
20	20324
21	21670
22	23462
23	25742
24	28537
25	31853
26	35659
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28	44397
29	48999
30	53407
31	57234
32	59978
33	60998
34	59496
35	54497

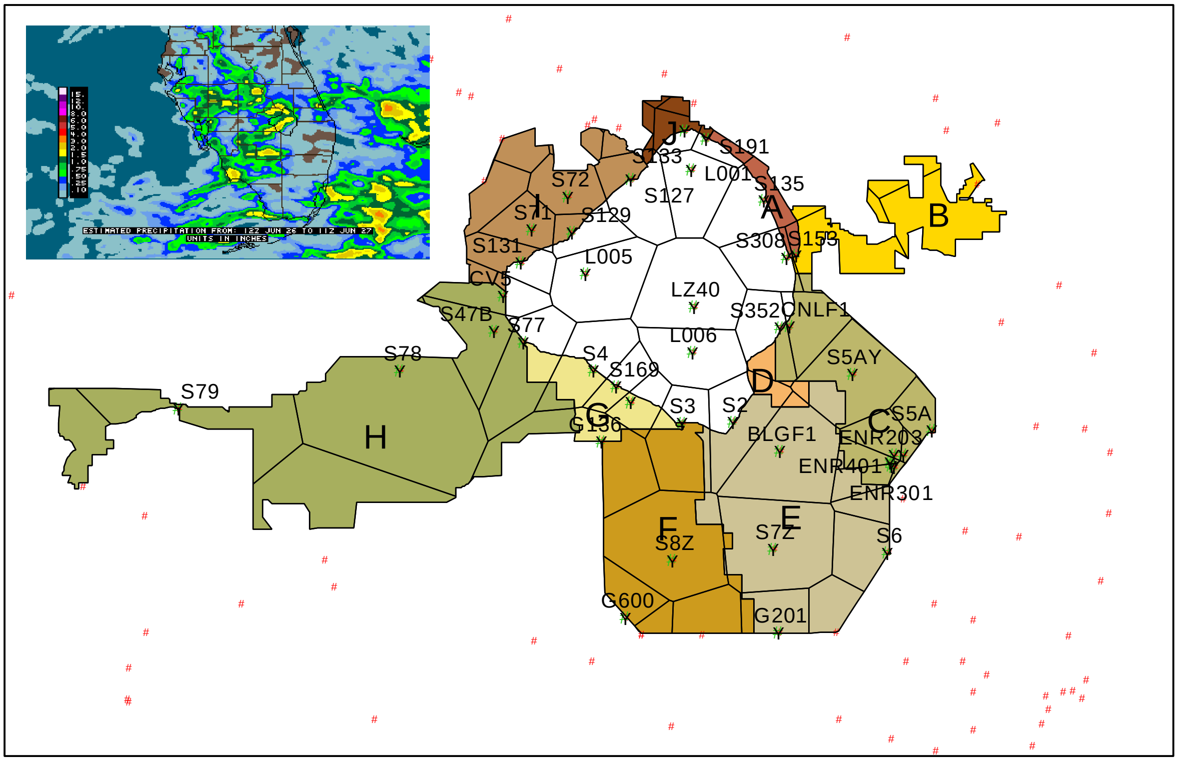

Figure 9. Rain Gauge Network and Radar Information Used to Calculate Thiessen-weighted Average Rainfall Values for the Ten LOSA Sub-basins

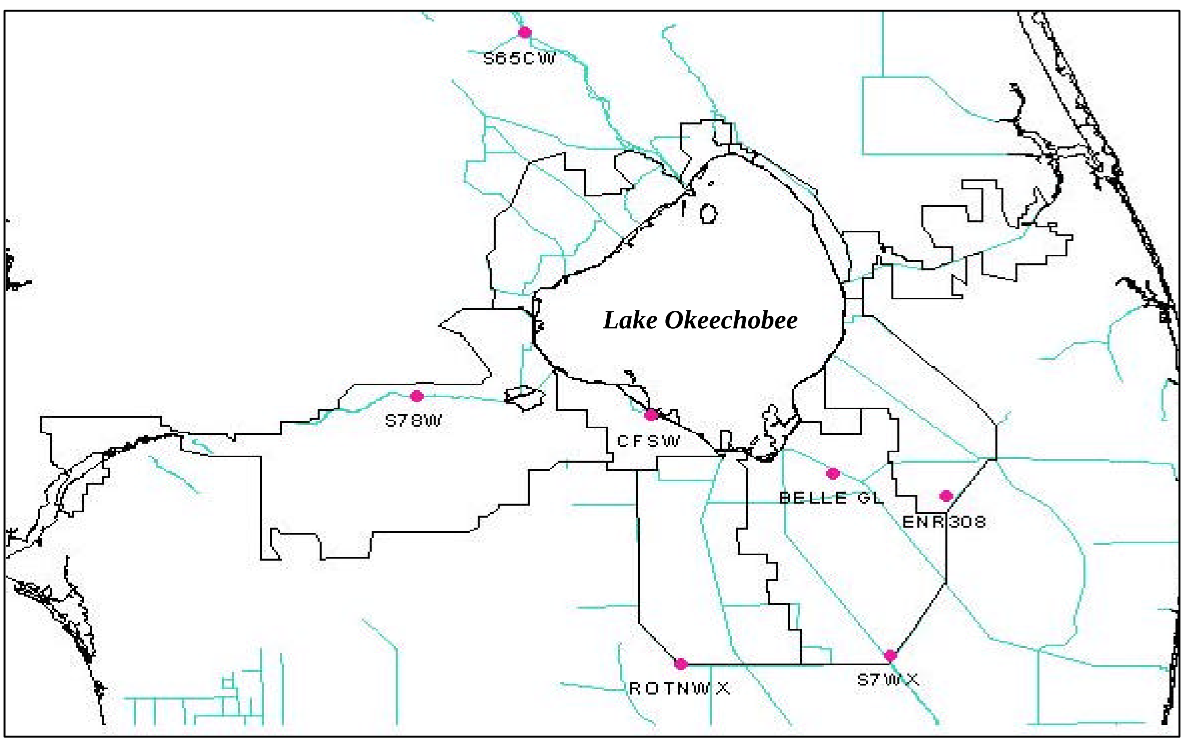

Figure 10. Location of Climatological Stations Used to Calculate Evapotranspiration for the Ten LOSA Sub-basins

Table 8. Assignment of Weather Stations to LOSA Sub-basins

LOSA Sub-basin	**Weather Station**
A: NORTHEAST LAKE SHORE	S65CW
B: ST. LUCIE (C-44)	ENR308
C: WPB CANAL & L-8	ENR308
D: E.BEACH & E.SHORE WCD	BELLE GL
E: N.NEW RIVER & HILLSBORO	Average of BELLE GL and S7WX
F: MIAMI CANAL BASIN	ROTNWX
G: C-21 & S-236 BASINS	CFSW
H: CALOOSAHATCHEE (C-43)	S78W
I: NORTHWEST LAKE SHORE	S78W
J: NORTH LAKE SHORE	S65CW

C. Reference Elevation Adjustments

One of the most important features in SSM from a computational standpoint is the reference elevation due to its relationship with allocable volume in Lake Okeechobee. Under most conditions, the reference elevation is fixed at a lake stage of 10.5 feet NGVD. However, as previously stated, when water levels within Lake Okeechobee fall below, or can be expected to fall below the June 1st lake stage of 10.5 feet NGVD, temporary revisions can be made to the reference elevation under Rule 40E-21 F.A.C. Under this scenario, the District's Drought Management Team is charged with the "day to day operational decisions associated with implementing the temporary revised reference elevation." The determination of a temporary reference elevation requires a careful balance of many factors. These include available storage in the lake, projected demands of all users of the lake, drought severity (expected rainfall, inflows and evapotranspiration losses), environmental health of the lake and the Everglades, navigation, saltwater intrusion in the estuaries and economic impacts. Outlined below are several indicators that will be used by the District's Drought Management Team to determine when adjustments are needed to the temporary reference elevation. Each of these indicators as well as other hydrologic and biologic conditions within the regional system will be considered prior to changing the reference elevation.

1. Remaining Supplemental Demands

The District's Drought Management Team will keep track of the allocable volume remaining in each user’s account throughout the implementation of Supply Side Management. As previously documented, changes in Lake Okeechobee storage will be redistributed to share accounts on a weekly basis. In the event of extreme drought conditions in which Lake Okeechobee stage falls more quickly than anticipated, the allocable volume in share accounts may become too small to meet even a minimum level of service. The threshold at which this occurs can be quantified by comparing the account volume to projected demands for the remainder of the dry season. In the event that the remaining volume in share accounts is deemed to be to small to meet a minimum level of service, the District's Drought Management Team may consider lowering the reference elevation to increase allocable volume. Table 4 in Section III.B.2.a contains the cumulative demands to the end of the dry season for LOSA under different drought conditions.

2. Performance Measures

In setting the reference elevation, it is important to take into consideration the environmental health of Lake Okeechobee and navigation concerns within the lake itself. The SFWMD's Minimum Flows and Levels criteria, developed with these interests in mind and outlined in Rule 40E-8, F. A. C., state that significant harm occurs when water levels in Lake Okeechobee fall below 11 ft NGVD for more than 80 days duration, more often than once every six years, on average (SFWMD, 2000b). In setting the temporary revised reference elevation, the District's Drought Management Team will consider performance measures that relate the probability of adverse impacts in lake ecosystems and navigation to low lake stages and biological indicators. A list of these performance measures is provided in Table 9. Further detail regarding the effects of extreme low lake stage can be found in the SFWMD Minimum Flows and Levels document.

Table 9. Performance Measure scoring for Lake Okeechobee.

Performance Measure		**Scoring**
Adverse Biological Impacts*	no harm	
Level of severity defined as in the Minimum Flows & Levels (MFL) criteria	harm	
	significant harm	
MFL Violation	1	
Number of MFL exceedances within last six years	2	
	3	

Black = high probability of adverse impacts on the ecosystem
Grey = moderate probability of adverse impacts
White = low probability of adverse impacts

* Extracted from Lake Okeechobee Adaptive Protocols (SFWMD 2002)

3. Position Analysis

Position Analysis is a special form of risk analysis evaluated from the "present position" of the system. Its purpose is the evaluation of water resources systems and the risks associated with operational decisions (Hirsch 1978; Smith et al., 1992). This evaluation is accomplished by estimating the probability distribution function of variables related to the water resources system, conditional on the current or a specified state of the system. This provides an estimate of risk associated with a given plan of operation over a period of several months or the probability of being able/unable to achieve a "target" (e.g. Lake Okeechobee stage of 10.5 at the end of the dry season). To perform position analysis, the South Florida Water Management Model is used. Separate model simulations are initialized with the same "present/current position" of the South Florida system and are run with different climatic inputs. Position Analysis will be the tool used by district managers to project when Lake Okeechobee stages may fall below 10.5 ft. and temporary revisions to the reference elevation may be needed. Additionally, information related to Lake Okeechobee and the rest of the regional system will be obtained from the position analysis model simulations will be used in assessing the possible impacts of temporary revisions to the reference elevation.

4. Conveyance Limitations

Physical constraints can be a limiting factor in setting the SSM reference elevation. In general, there is significant difficulty in removing water from Lake Okeechobee when water levels fall below 10.2 ft NGVD. At this stage, the three major (gravity) outlet structures delivering water to the EAA and the Lower East Coast (S-354, S-351 and S-352) become essentially ineffective due to downstream head conditions. In the past, measures have been taken to augment the District's ability to make water supply deliveries out of Lake Okeechobee at low lake levels. By the early part of April 2001, forward pumps with a total capacity of 1,400 cfs were in full operation along the Miami, North New River and Hillsboro, and West Palm Beach canals. These pumps were installed to maintain water supply delivery of lake water to the EAA and/or the LEC as lake levels continued to recede below 10.2 ft NGVD. It is important to note, however, that the total capacity of the forward pumps is not sufficient to meet both the EAA and LEC demands.

5. Economic Impacts

The effects of low lake stage can have a significant impact on the economic viability of the region surrounding Lake Okeechobee. The effects of water restrictions on agriculture in LOSA could result in a reduction in product as well as increases in operational costs. Additionally, if lake levels fall low enough, businesses that promote Lake Okeechobee for recreational purposes and businesses dependent on tourism related to the lake could face severe economic hardship due to impacts on the Lake’s littoral zone, fisheries and navigable channels. The District's Drought Management Team will consider these economic impacts in conjunction with the other items outlined in the above sections.

D. Reporting Procedures

Information related to Supply Side Management implementation will be distributed via many channels to water users and the public in general. Regular reporting of the current water supply outlook will be made to the SFWMD Governing Board during its monthly meeting or special sessions. In addition, similar reports will be made to the Water Resources Advisory Commission (WRAC) for the duration of the drought. Allocations (e.g. on farm water use) and information pertaining to share accounts will be posted to the Internet on a weekly basis. Other information related to SSM methodology and implementation will also be made available to the public via the Internet. In the event of a Phase III or greater declaration of water shortage, any temporary revisions or projected changes in the future to reference elevation will be reported to Governing Board on a monthly basis.

IV. Sample Calculations

In order to illustrate the updated SSM procedure as outlined in Section III, a simplified sample calculation for the weeks of October 29, 2002 (dry season week 5) and November 5, 2002 (dry season week 6) is detailed below. This example assumes that there will only be three share accounts: LOSA agriculture, the LEC and the Seminole Tribe (Brighton and Big Cypress Reservations). For example purposes, these accounts will serve to demonstrate the computational aspects of the method. It is important to note, however, that in actual implementation, there would be many other accounts. In practice, the SSM calculation would be made on Monday each week and implementation of its results would begin on the corresponding Wednesday, the day of the week selected by agricultural users for convenience of irrigation planning.

<u>Assumptions for Hypothetical Example</u>:

- October 29, 2002 Lake Okeechobee stage is 12.80 ft. and SSM is first implemented.
- Lake Okeechobee Reference Elevation is 10.50 ft.
- The Drought Monitor indicates a "moderate drought" across the SFWMD.
- There will be three share accounts: LOSA, LEC and SEM
- The Seminole Tribe will be allocated 400 acre-feet of Lake Okeechobee water every week in the dry season.

<u>First Week of Implementation</u>:

1. Calculation of Allocable Volume:

- Storage @ 12.80 ft = 3,031,000 acre-feet (see Appendix B)
- Storage @ 10.50 ft = 2,203,000 acre-feet

- Available Storage = 3,031,000 acre-feet - 2,203,000 acre-feet
  = 828,000 acre-feet

- A "moderate drought" corresponds to a 1-in-5 condition. According to Table 2, the expected net storage change (including inflows) between October 29th (week 5) and the end of the dry season for a 1-in-5 condition is -586,565 acre-feet.

- Allocable Volume = 828,000 acre-feet - 586,565 acre-feet
  = 241,435 acre-feet

2. Initial Distribution of Allocable Volume to Share accounts:

- Type I accounts: LOSA, LEC
  Type II account: SEM

- Allocable Volume (SEM) = 400 acre-feet * 31 remaining dry season weeks
  = 12,400 acre-feet

- Remaining Allocable Volume = Allocable Volume minus Type II accounts
  = 241,435 acre-feet minus 12,400 acre-feet
  = 229,035 acre-feet

- According to Tables 4 and 5, for a moderate drought, the remaining dry season demands for week 5 in LOSA and the LEC are 583,732 acre-feet and 106,651 acre-feet, respectively.

- Allocable Volume (LOSA) = 229,035 acre-feet * 583,732/(583,732 + 106,651)
  = 193,653 acre-feet

- Allocable Volume (LEC) = 229,035 acre-feet * 106,651/(583,732 + 106,651)
  = 35,382acre-feet

- Account Summary (Ledgers); all volumes in acre-feet.

Account	LOSA	LEC	SEM	Total
Initial Volume	193,653	35,382	12,400	**241,435**

As can be seen, the total volume in all accounts is equal to the allocable volume calculated in step 1.

3. Account Management - Preliminary Calculations:

- According to Table 6, the weekly allocation factor for week 5 for a moderate drought is 0.0240190

- Preliminary Allocation (LOSA) = 193,653 acre-feet * 0.0240190
  = 4,651 acre-feet

Account Management - Determination of Allocation (Withdrawals):

- Let us assume that LOSA has been dry (according to AFSIRS) and requires more allocation and that the LEC will not require deliveries.

- In Table 7, the 1-in-10 weekly LOSA demand for week 5 is 23,217 acre-feet (of which LOSA may use up to 50%).

- Max Allocation (LOSA) = (23,217 Acre-feet) * 50%
  = 11,609 acre-feet

- Account Summary (Ledgers); all volumes in acre-feet.

Account	LOSA	LEC	SEM	Total
Initial Volume	193,653	35,382	12,400	241,435
Withdrawal	- 11,609	0	-400	-12,009
Account Balance	182,044	35,382	12,000	229,426

<u>Second Week of Implementation</u>:

- Assume November 5, 2002 Lake Okeechobee stage is 12.72 ft.

1. Calculation of Allocable Volume:

- Storage @ 12.72 ft = 3,000,000 acre-feet
- Storage @ 10.50 ft = 2,203,000 acre-feet

- Available Storage = 3,000,000 acre-feet - 2,203,000 acre-feet
  = 797,000 acre-feet

- According to Table 2, the expected net storage change between November 5th (week 6) and the end of the dry season for a 1-in-5 condition is -561,985 acre-feet.

- Allocable Volume = 797,000 acre-feet - 561,985 acre-feet
  = 235,015 acre-feet

2. Storage Redistribution:

- To calculate the storage redistribution volume, the current and previous week's allocable volume and the previous week's withdrawals must be known. This volume (positive or negative) will then be distributed to Type I accounts in a similar manner as in the first week of implementation.

- Storage Redistribution = 235,015 acre-feet - 241,435 acre-feet - (- 12,009 acre-feet)
  = 5,589 acre-feet

- According to Tables 4 and 5, for a moderate drought, the remaining dry season demands for week 6 in LOSA and the LEC are 566,969 acre-feet and 106,651 acre-feet, respectively.

- Redistribution Volume (LOSA) = 5,589 acre-feet * 566,969 /(566,969 + 106,651)
  = 4,704 acre-feet

- Redistribution Volume (LEC) = 5,589 acre-feet * 106,651/(566,969 + 106,651)
  = 885 acre-feet

- Account Summary (Ledgers); all volumes in acre-feet.

Account	**LOSA**	**LEC**	**SEM**	**Total**
Initial Volume	193,653	35,382	12,400	241,435
Withdrawal	- 11,609	0	-400	-12,009
Account Balance	182,044	35,382	12,000	229,426
Storage Redistribution	4,704	885	0	5,589
Account Balance	186,748	36,267	12,000	**235,015**

Once again, the total volume in all accounts is equal to the allocable volume calculated in step 1.

3. Account Management - Preliminary Calculations:

- According to Table 6, the weekly allocation factor for week 6 for a moderate drought is 0.0252223

- Preliminary Allocation (LOSA) = 186,748 acre-feet * 0.0252223
  = 4,710 acre-feet

Account Management - Determination of Allocation (Withdrawals):

- Let us assume that LOSA wishes to receive no allocation and reserve water in the account for later use because local rainfall is meeting current needs. Also, let us assume that the LEC will require 1000 acre-feet in water supply deliveries.

- Account Summary (Ledgers); all volumes in acre-feet.

Account	LOSA	LEC	SEM	Total
Initial Volume	193,653	35,382	12,400	241,435
Withdrawal	- 11,609	0	-400	-12,009
Account Balance	182,044	35,382	12,000	229,426
Storage Redistribution	4,704	885	0	5,589
Account Balance	186,748	36,267	12,000	235,015
Withdrawal	0	- 1,000	- 400	-1,400
Account Balance	186,748	35,267	11,600	233,615

Third Week of Implementation to End of Implementation:

- Repeat Procedure used for Second Week

V. Summary

Lessons learned from the past year resulted in a need to redefine some of the assumptions and revisit the calculation method associated with SSM1991. Although some of the issues associated with supply side management, especially on the implementation side, require policy decision-making, this document attempts to define the technical aspects of the updated SSM plan. It serves as a guideline to the entire process of allocating water to the various users of Lake Okeechobee water during drought conditions.

The perceived weaknesses of SSM1991 are:

1. Does not account for users of lake water other than LOSA agriculture except through reference stage adjustments
2. Assumes normal conditions to quantify allocable water for the entire season although this may not be consistent with actual field conditions
3. Lake Okeechobee water budget does not consider tributary inflows, a major component of the budget
4. Does not address environmental concerns related to Lake Okeechobee
5. Rainfall and supplemental irrigation estimates are outdated
6. Evapotranspiration estimation method is limited

7. Spatial distribution of demand for agricultural allocation is unclear
8. Borrowing scheme for agricultural users lacks flexibility

The changes to SSM1991, incorporated into the updated SSM methodology are:

1. Switch in methodology to a volumetric approach that provides a clearer picture of Lake Okeechobee water budget components and handles short-term fluctuations in demand better than borrowing
2. Explicit consideration of water resources outlook, performance measures, MFL criteria and other factors in determining reference elevation changes.
3. Incorporation of new estimates of Lake Okeechobee rainfall, evapotranspiration, and tributary inflows with adjustments consistent with prevailing drought severity
4. Use of real-time climatic data to determine water demands in LOSA sub-basins

While the updated computational procedure associated with the revised SSM methodology is straightforward, the complexity associated with managing several users of lake water on a weekly time step during drought periods is also evident. Despite this complexity, the updated SSM methodology in conjunction with the other measures (including the District's Water Shortage Plan and the Minimum Flows & Levels rule) provide a sound and equitable framework within which to manage water resources during periods of shortage.

Glossary (Some terms as defined in the LECRWSP, SFWMD 2000a)

1995 Base Case or 95BSRR A simulation using the South Florida Water Management Model (see Appendix A) which provides an understanding of the how the1995 water management system with 1995 land use and demands responds to historic (1965-1995) climatic conditions as described in the Lower East Coast Regional Water Supply Plan.

AFSIRS A surface water water budget model which is used to approximate surface water availability in each of the major surface water sub-basins in order to quantify the demands that could not be satisfied by surface water

Allocation Factor The fraction of the current period's allocation (or demand) over the total allocation (or demand) from the same period up to the end of the dry season; Represents the portion of the remaining available lake water that can be used for the current period that reasonably distributes (in time) withdrawal of lake water through the end of the dry season. Allocation factors increase as the end of the dry season is approached.

C&SF Project Comprehensive Review Study (Restudy) A five-year study effort that looked at modifying the current C&SF Project to restore the greater Everglades and South Florida ecosystem while providing for the other water-related needs of the region. The study concluded with the Comprehensive Plan being presented to the Congress on July 1, 1999. The recommendations made within the Restudy, that is, structural and operational modifications to the C&SF Project, are being further refined and will be implemented in the Comprehensive Everglades Restoration Plan (CERP).

Comprehensive Everglades Restoration Plan (CERP) The recommendations made within the Restudy, that is, structural and operational modifications to the C&SF Project are being further refined and will be implemented through this plan.

Everglades Agricultural Area (EAA) The area of histosols (muck) predominantly to the Southeast of Lake Okeechobee which is used for agricultural production.

Everglades Construction Project The foundation for the largest ecosystem restoration program in the history of Florida. It is composed of 12 inter-related construction projects located between Lake Okeechobee and the Everglades, including over 47,000 acres of Stormwater Treatment Areas (STAs).

Minimum Flows and Levels (MFL) The point at which further withdrawals would cause significant harm to the water resources.

Reference Elevation A 'tool' used to determine allocable volume in Lake Okeechobee for a given date. Requires a careful balance of storage in the lake, projected demands of all users of the lake, drought severity, environmental health of the lake and the remaining Everglades, navigation, and economic impacts.

Regional Water Supply Plan Detailed water supply plan developed by the District under Chapter 373.0361, Florida Statutes.

Share Account an individually maintained ledger that represents a volume of water available to a particular user (through the end of the dry season) as calculated by the SSM computational procedure.

South Florida Water Management Model (SFWMM) An integrated surface water-ground water model that simulates the hydrology and associated water management schemes in the majority of South Florida using climatic data from January 1, 1965, through December 31, 1995. The model simulates the major components of the hydrologic cycle and the current and numerous proposed water management control structures and associated operating rules. It also simulates current and proposed water shortage policies for the different subregions in the system. See Appendix A for further detail.

SSM1991 A computational procedure that complemented the District's overall Water Shortage Plan documented in 1991 by A. Hall; The "yellow book" version of Supply-Side Management. The updated SSM procedure based recommendations made during the 2000-2001 drought supercedes SSM1991.

Stormwater Treatment Area (STA) A system of large treatment wetlands that use naturally occurring biological processes to reduce the levels of phosphorus from agricultural runoff prior to it being released to the Everglades.

Supply-Side Management The conservation of water in Lake Okeechobee to ensure that water demands are met while reducing the risk of serious or significant harm to natural systems.

Supplemental Irrigation The amount of water required to meet ET requirements of a crop after net rainfall or local sources have been depleted. For LOSA, supplemental irrigation comes from Lake Okeechobee.

Type I Share Account An account whose volume is affected on a weekly basis by changes in LOK allocable storage.

Type II Share Account An account whose volume is not affected on a weekly basis by changes in LOK allocable storage.

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Appendix A

South Florida Water Management Model Version 3.7

Documentation of the SFWMM (SFWMD 1999) may be viewed over the Internet by visiting http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/index.html. This documentation contains descriptions of the physical, hydrologic, and system management components of the model as well as information related to model calibration, sensitivity and uncertainty.

Excerpts from the LECRWSP:

The South Florida Water Management Model version 3.7 (SFWMM v3.7) is a regional-scale computer model that simulates the hydrology and the management of the water resources system from Lake Okeechobee to Florida Bay. It covers an area of 7,600 square miles using a mesh or grid of two mile by two mile cells. The model boundaries include Lake Okeechobee, the Everglades Agricultural Area (EAA), the WCAs, Everglades National Park, the LEC urban areas, and parts of the Big Cypress National Preserve. Inflows from Kissimmee River, and runoff and demands in the Caloosahatchee River and St. Lucie Canal basins are considered. The model simulates major components of the hydrologic cycle in South Florida including rainfall, evapotranspiration, infiltration, overland and ground water flow, canal flow, canal-ground water seepage, levee seepage, and ground water pumping. It incorporates physical and operational features for current or proposed water control structures, pump stations, and canals. The ability to simulate water shortage policies affecting urban, agricultural, and environmental water uses in South Florida is a major strength of this model.

The SFWMM is an integrated surface water-ground water model that simulates hydrology on a daily basis using climatic data for the 1965-1995 period, which includes droughts and wet periods. The model has been calibrated and verified using water level and discharge measurements at hundreds of locations distributed throughout the region within the model boundaries. Output of the model includes Lake Okeechobee stages and discharge information, surface and ground water levels, overland flow, and evapotranspiration at any of the four-square-mile model grid. The SFWMM was developed in the early 1980s by the District for the USACE and has been extensively modified and improved during the past 14 years. The model has been used for a number of applications to evaluate proposed structural or operational changes to regional water management facilities. Technical staffs of many federal, state, and local agencies, and public and private interest groups have accepted the SFWMM as the best available tool for analyzing regional-scale structural and operational changes to the complex water management system in South Florida.

The SFWMM was used in this plan because the hydrology of South Florida is complex, due to the flat topography, high water table, sandy soils, and high conductivity of the aquifer system. With the rapid population growth, the water control system in South Florida has been expanded and its operation has become increasingly automated, resulting in a unique system. The SFWMM, developed specifically for this region, is probably the best available tool that can simulate the complex system features and operational rules of proposed regional water management alternatives and provide adequate information for making water management decisions. Additional information on the SFWMM can be found in Appendix E of the LECRWSP (SFWMD, 2000a).

Appendix B

Lake Okeechobee Stage - Storage Relationship

Stage (feet)	Storage (1000 acre-feet)	Stage (feet)	Storage (1000 acre-feet)	Stage (feet)	Storage (1000 acre-feet)	Stage (feet)	Storage (1000 acre-feet)	Stage (feet)	Storage (1000 acre-feet)
8.00	1442	12.50	2915	17.00	4875	21.50	6965	26.00	9140
8.10	1471	12.60	2954	17.10	4920	21.60	7010	26.10	9190
8.20	1499	12.70	2992	17.20	4965	21.70	7055	26.20	9240
8.30	1528	12.80	3031	17.30	5010	21.80	7105	26.30	9290
8.40	1557	12.90	3069	17.40	5060	21.90	7150	26.40	9340
8.50	1586	13.00	3108	17.50	5106	22.00	7195	26.50	9390
8.60	1614	13.10	3150	17.60	5150	22.10	7245	26.60	9440
8.70	1643	13.20	3192	17.70	5195	22.20	7290	26.70	9490
8.80	1672	13.30	3234	17.80	5240	22.30	7340	26.80	9540
8.90	1700	13.40	3276	17.90	5290	22.40	7390	26.90	9590
9.00	1729	13.50	3317	18.00	5335	22.50	7435	27.00	9640
9.10	1760	13.60	3359	18.10	5380	22.60	7480	27.10	9690
9.20	1791	13.70	3401	18.20	5425	22.70	7530	27.20	9740
9.30	1822	13.80	3443	18.30	5470	22.80	7580	27.30	9790
9.40	1853	13.90	3485	18.40	5515	22.90	7625	27.40	9840
9.50	1884	14.00	3527	18.50	5565	23.00	7670	27.50	9890
9.60	1915	14.10	3575	18.60	5610	23.10	7720	27.60	9940
9.70	1946	14.20	3620	18.70	5655	23.20	7770	27.70	9990
9.80	1977	14.30	3665	18.80	5700	23.30	7820	27.80	10040
9.90	2008	14.40	3710	18.90	5745	23.40	7870	27.90	10090
10.00	2039	14.50	3755	19.00	5790	23.50	7920	28.00	10140
10.10	2072	14.60	3800	19.10	5835	23.60	7970	28.10	10200
10.20	2105	14.70	3845	19.20	5880	23.70	8010	28.20	10250
10.30	2137	14.80	3890	19.30	5930	23.80	8060	28.30	10300
10.40	2170	14.90	3935	19.40	5980	23.90	8110	28.40	10350
10.50	2203	15.00	3980	19.50	6030	24.00	8150	28.50	10400
10.60	2236	15.10	4020	19.60	6075	24.10	8200	28.60	10450
10.70	2269	15.20	4065	19.70	6120	24.20	8250	28.70	10500
10.80	2301	15.30	4110	19.80	6170	24.30	8300	28.80	10550
10.90	2333	15.40	4155	19.90	6215	24.40	8350	28.90	10600
11.00	2366	15.50	4200	20.00	6260	24.50	8400	29.00	10650
11.10	2402	15.60	4245	20.10	6310	24.60	8440	29.10	10700
11.20	2437	15.70	4290	20.20	6355	24.70	8490	29.20	10750
11.30	2473	15.80	4335	20.30	6400	24.80	8540	29.30	10800
11.40	2508	15.90	4380	20.40	6445	24.90	8590	29.40	10850
11.50	2544	16.00	4425	20.50	6495	25.00	8640	29.50	10910
11.60	2580	16.10	4470	20.60	6540	25.10	8690	29.60	10960
11.70	2615	16.20	4515	20.70	6585	25.20	8740	29.70	11010
11.80	2651	16.30	4560	20.80	6630	25.30	8790	29.80	11060
11.90	2686	16.40	4605	20.90	6680	25.40	8840	29.90	11110
12.00	2722	16.50	4650	21.00	6730	25.50	8890	30.00	11160
12.10	2761	16.60	4695	21.10	6775	25.60	8940		
12.20	2799	16.70	4740	21.20	6820	25.70	8990		
12.30	2838	16.80	4785	21.30	6870	25.80	9040		
12.40	2876	16.90	4830	21.40	6920	25.90	9090		